Monitoring statistics of the ERS-2 scatterometer for ESA

CYCLE 75

(Project Ref. 15988/02/I-LG)

Hans Hersbach
European Centre for Medium-Range Weather Forecasts,
Shinfield Park, Reading, RG2 9AX, England
Tel: (+44 118) 9499476, e-mail: dal@ecmwf.int

August 9, 2002

1 Introduction

From 12 December 2001 onwards, ESRIN redistributes ERS-2 scatterometer data to a selected group of users. The quality of this experimental gyroless product was monitored at ECMWF for cycle 75. The gyroless ERS-2 scatterometer data was not used in the 4D-Var data assimilation system at ECMWF.

During cycle 75, data was received between 21:03 UTC 17 June 2002 and 20:57 UTC 22 July 2002. No data was received for the 6-hourly cycles: 06 UTC 21 June 2002, 12 UTC 21 June 2002, 18 UTC 25 June 2002, 00 UTC 15 July 2002, and 18 UTC 18 July 2002.

For high incidence angles the quality of the data that was received during cycle 75 was higher than the average performance of the data received during cycle 74. For the lowest incidence angles, the opposite was observed. Around 29 June 2002 and 14 July 2002 there were jumps towards better performance. As a result, from 14 July 2002 to the end of period 75 the quality of the UWI winds was found to be quite good. Although the bias level of the UWI winds is 0.35 m/s more negative than it was during cycle 59 (December 2000, i.e., the last cycle in nominal mode), the standard deviation is actually 0.04 m/s better. The more negative bias is due to a remaining negative bias in the sigma0 levels (see next section). In principle, it is possible to correct for this. It is unclear what part of the reduced standard deviation w.r.t. cycle 59 is to be credited to the UWI winds, or to improved ECMWF first-guess winds since December 2000 (e.g., due to the assimilation of QuikSCAT winds).

During cycle 75, there was no clear signature found for data that was degraded by solar activity.

The ECMWF assimilation system was not modified during cycle 75.

2 ERS-2 statistics from 18 June 2002 to 22 July 2002

2.1 Sigma0 bias levels

The average sigma0 bias levels (compared to simulated sigma0's based on ECMWF model first-guess winds, see Figure 1) for cycle 75 as compared to the corresponding levels averaged over cycle 74, showed the following evolution. The bias levels for the fore and mid beam remained more or a less unchanged; i.e., reasonably independent on incidence angle, and about 0.6 dB too low. Like for cycle 74, only for high incidence angles the bias of the fore beam is more negative. However, the bias level for the aft beam has improved considerably. Although it became 0.3 dB more negative for low and medium incidence angles, the large negative values for high incidence angles were largely suppressed (0.3 dB less). As a result, bias levels are very similar for all three beams and much less dependent on incidence angles. The average level, however, is around 0.6 dB lower than its nominal value, which will introduce negative biases in the speeds of the inverted wind vectors.

2.2 Distance to cone history

The distance to the cone history is shown in Figure 2. From this it is clearly seen that for the lower nodes there is a sudden drop in the average levels at 18 UTC 28 June 2002. Since that date, for these lower nodes, average levels are much closer to 1, which was the average distance during the nominal period. For the higher nodes this jump is not visible. However, around 14 July 2002, average levels for these higher nodes tend to become somewhat lower as well.

Besides some smaller ones, the cone history shows peaks for 12 UTC 22 June 2002, 00 UTC 6 July 2002 and 00 UTC 9 July 2002. For all of these three peaks, the bias of the UWI winds compared to ECMWF first-guess winds (Figure 3) is more negative than average. The event of 00 UTC 9 July 2002 is the most intense one. It is also accompanied with a peak in the standard deviation between the UWI and ECMWF winds. The large negative wind biases indicate that within these 6-hourly periods the attitude in yaw has probably been outside the required accuracy of 2 degrees.

2.3 UWI minus First-Guess history

The drop in the normalized distance in the cone at 18 UTC 28 June 2002 is also visible in the UWI minus ECMWF first-guess wind history plots (Figure 3). For the lower nodes the standard deviation has become smaller. However, the bias levels have become more negative. The drop in cone distance around 14 July had also an effect on the UWI winds. For medium and higher nodes standard deviations have become smaller. There is no effect on the UWI wind bias for these nodes. However, bias levels for the lower nodes seem to become slightly less negative again (though still worse than the situation before 28 June 2002).

Since the transition around 14 July, the UWI bias history has become less volatile. Since that date no negative peaks (associated with inaccuracies in the yaw steering) were reported. However, between the transition at 8 UTC 28 June 2002 and 14 July 2002, there were several of those peaks. Many of them were associated with peaks in the distance to cone history, and, therefore, could have been rejected beforehand on that ground.

For the history plot of the de-aliased CMOD4 winds versus the ECMWF first-guess winds a very similar behaviour was observed (Figure 5).

For higher incidence angles, the quality of the UWI winds received during cycle 75 was higher w.r.t. data received during cycle 74. For the lowest nodes, the opposite was observed. The UWI winds now have an average bias of -1.10 m/s, which was -1.00 m/s for cycle 74. The bias is -1.37 m/s for nodes 1-2 (was -1.14 m/s) and -1.12 m/s for nodes 15-19 (was -1.18 m/s). Biases are smallest for nodes 8-10 (-0.94 m/s, was -0.82 m/s). The standard deviation is on average 1.62 m/s (was 1.65 m/s), and increases from 1.58 m/s (was 1.57 m/s) for nodes 1-2, to 1.67 m/s for nodes 15-19 (was 1.72 m/s). Very similar results apply to the de-aliased CMOD4 winds.

The (scatterometer - model) direction standard deviations (Figure 4) were ranging between 40 and 60 degrees for the UWI data (average value 54.0 degrees, was 52.9) and between 15 and 25 degrees (average value 19.2, was 20.6) for their de-aliased counterparts (Figure 6). The directional bias is close to zero for both UWI and de-aliased CMOD4 products. Therefore, the skill in wind direction has become slightly worse for the UWI winds, but slightly better for the de-aliased CMOD4 winds.

2.4 Scatter plots

The scatter plot of model 10 m first-guess wind speeds versus UWI wind speeds (Figure 7) shows a more negative bias (-1.10 m/s) compared to the plot from cycle 74 (-1.00 m/s). The standard deviation is smaller (1.64 m/s, was 1.67 m/s). The amount of low wind data with collocated first-guess winds that are much stronger is slightly higher than it was for cycle 74. Such data points are likely to be identified with situations in which inaccurate knowledge of yaw attitude leads to a partial destruction of backscatter and, therefore, inversion results into too low winds.

The direction scatter plot (Figure 8) looks similar to the results from cycle 74 (bias from 1.4 to 1.7 degrees, and standard deviation from 51 to 52 degrees).

Scatter plots were also made for the period between 00 UTC 14 July 2002 and 18 UTC 22 July 2002 (i.e., the end of cycle 75). For this period, the scatter plot of model 10 m first-guess wind speeds versus UWI wind speeds is shown in Figure 9. It is seen that for this period, the bias of the UWI winds is marginally better than for the whole period of cycle 75 (-1.08 m/s, compared to -1.10 m/s). The standard deviation of the winds, however, has improved substantially (from 1.62 m/s to 1.58 m/s).

In Figure 10, scatter plots for (de-aliased) winds inverted on the basis of the new CMOD5 formulation (developed at ECMWF in 2002) are presented These winds have a lower bias (-0.82 m/s) compared to the ECMWF first-guess winds and a smaller standard deviation as well (1.56 m/s). In the high wind-speed sector these CMOD5 winds are more realistic than their CMOD4 counterparts. As mentioned above, the negative bias is induced by the negative biases in the sigma0 levels (see Figure 1).

Figure Captions

Figure 1: Ratio of $< \sigma_0^{0.625} > / < \mathrm{CMOD4(FirstGuess)}^{0.625} >$ converted in dB for the for beam (solid line), mid beam (dashed line) and aft beam (dotted line), as a function of incidence angle for descending and ascending tracks. The thin lines indicate the error bars on the estimated mean. First-guess winds are based on the in time closest (+3h, +6h, +9h, or +12h) T511 forecast field, and are bilinearly interpolated in space.

Figure 2: Mean normalised distance to the cone computed every 6 hours for nodes 1-2, 3-4, 5-7, 8-10, 11-14 and 15-19 (solid curve close to 1 when no instrumental problems are present). The dotted curve shows the number of incoming triplets in logarithmic scale (1 corresponds to 60,000 triplets) and the dashed one indicates the fraction of complete sea-located triplets rejected by the ESA flag, or by the wind inversion algorithm (0: all data kept, 1: no data kept).

Figure 3: Mean (solid line) and standard deviation (dashed line) of the wind speed difference UWI - first guess for the data retained by the quality control.

Figure 4: Same as Fig. 3, but for the wind direction difference. Statistics are computed only for wind speeds higher than 4 m/s.

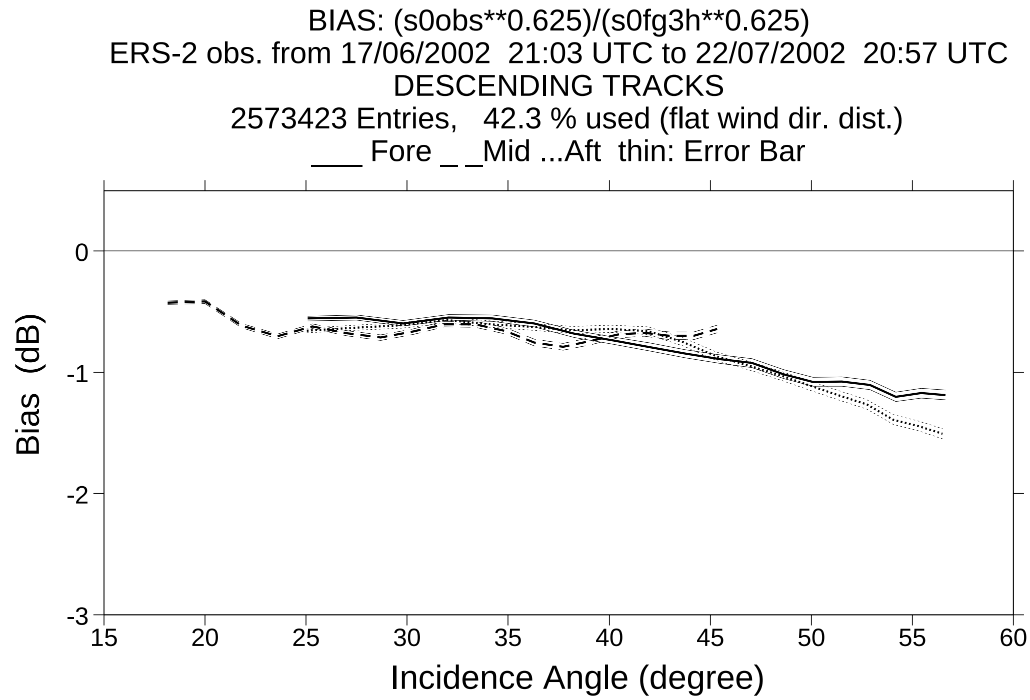
Figures 5 and 6: Same as Fig. 3 and 4 respectively, but for the de-aliased CMOD4 data.

Figure 7: Two-dimensional histogram of first guess and UWI wind speeds, for the data kept by the quality control. Circles denote the mean values in the y-direction, and squares those in the x-direction.

Figure 8: Same as Fig. 7, but for wind direction. Only wind speeds higher than 4m/s are taken into account.

Figures 9: Same as Fig. 7 and 8 respectively, but for the period between 00 UTC 14 July 2002 and 18 UTC 22 July 2002.

Figures 10: Same as Fig. 9, but for winds inverted on the basis of CMOD5; an improved geophysical model function developed at ECMWF.


BIAS: (s0obs**0.625)/(s0fg3h**0.625)
ERS-2 obs. from 17/06/2002 21:03 UTC to 22/07/2002 20:57 UTC
DESCENDING TRACKS
2573423 Entries, 42.3 % used (flat wind dir. dist.)
___ Fore _ _Mid ...Aft thin: Error Bar
Bias (dB)
0
-1
-2
-3
15
20
25
30
35
40
45
50
55
60
Incidence Angle (degree)

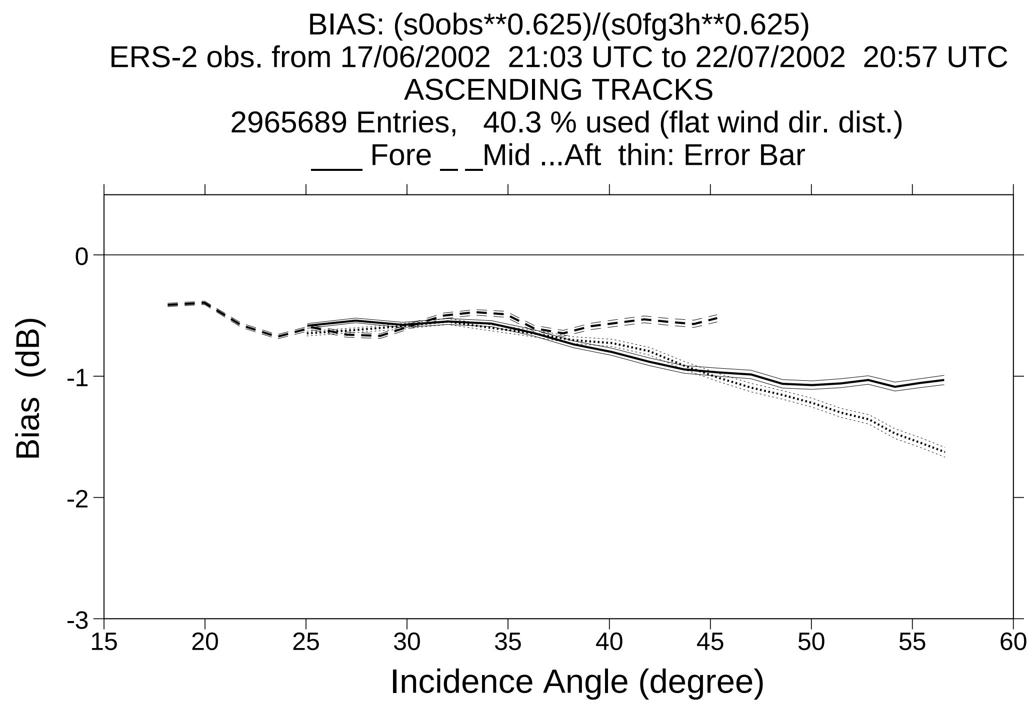

BIAS: (s0obs**0.625)/(s0fg3h**0.625)
ERS-2 obs. from 17/06/2002 21:03 UTC to 22/07/2002 20:57 UTC
ASCENDING TRACKS
2965689 Entries, 40.3 % used (flat wind dir. dist.)
___ Fore _ _Mid ...Aft thin: Error Bar
Bias (dB)
0
-1
-2
-3
15
20
25
30
35
40
45
50
55
60
Incidence Angle (degree)

Figure 1

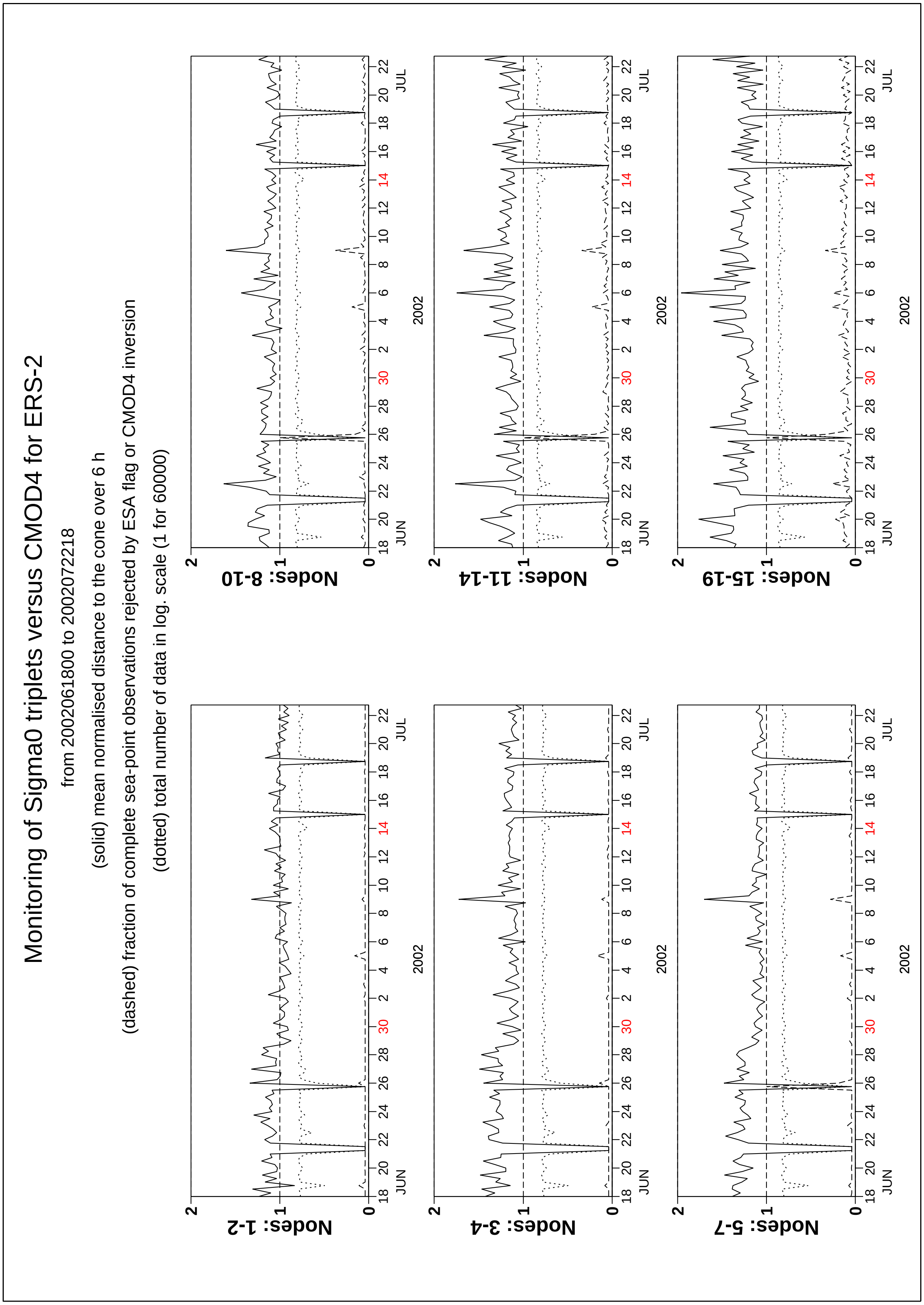

Monitoring of Sigma0 triplets versus CMOD4 for ERS-2
from 2002061800 to 2002072218
(solid) mean normalised distance to the cone over 6 h
(dashed) fraction of complete sea-point observations rejected by ESA flag or CMOD4 inversion
(dotted) total number of data in log. scale (1 for 60000)
Nodes: 1-2
Nodes: 3-4
Nodes: 5-7
Nodes: 8-10
Nodes: 11-14
Nodes: 15-19
JUN
JUL
2002

Figure 2

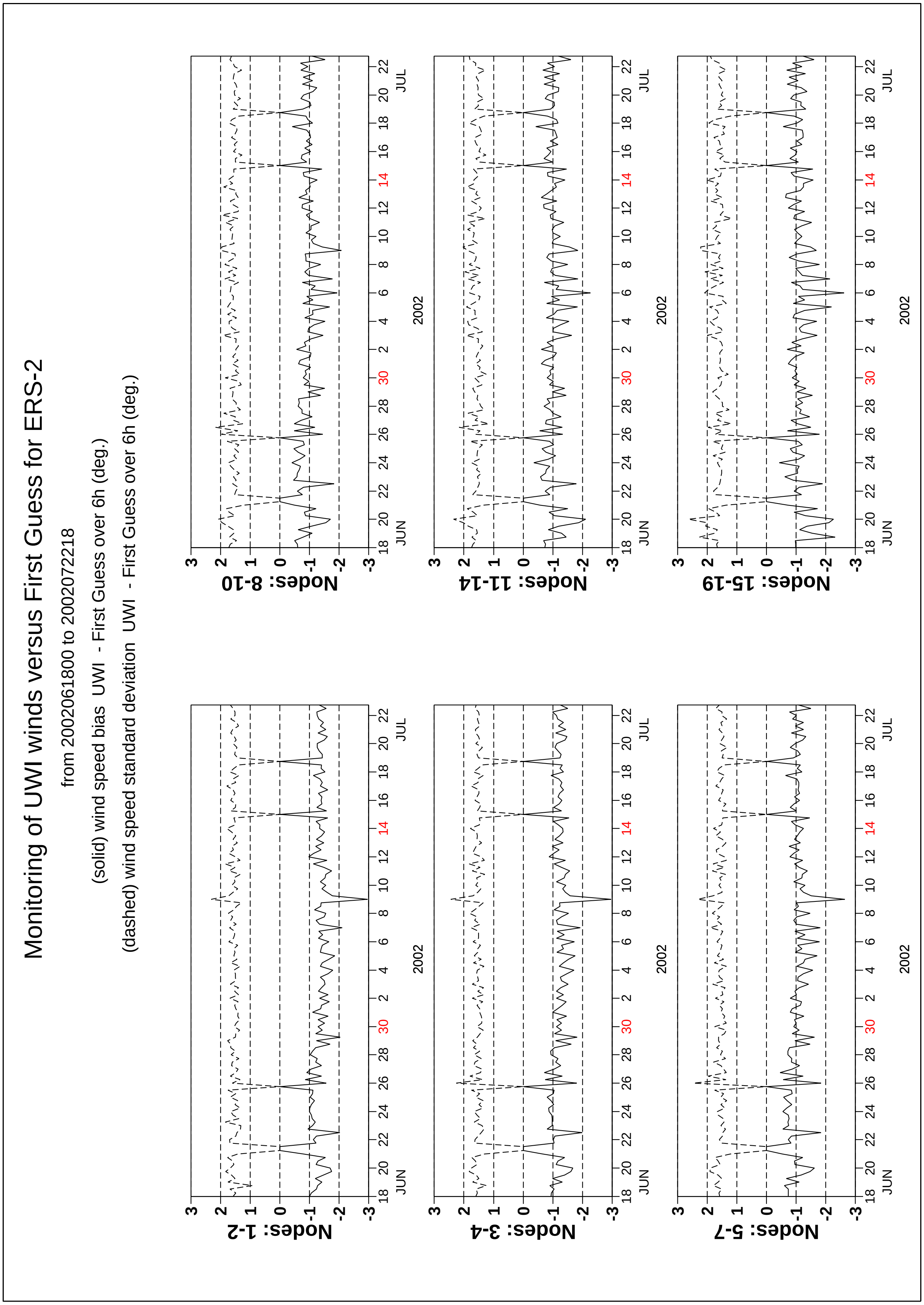

Monitoring of UWI winds versus First Guess for ERS-2
from 2002061800 to 2002072218
(solid) wind speed bias UWI - First Guess over 6h (deg.)
(dashed) wind speed standard deviation UWI - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 3-4
Nodes: 5-7
Nodes: 8-10
Nodes: 11-14
Nodes: 15-19
JUN
JUL
2002

Figure 3

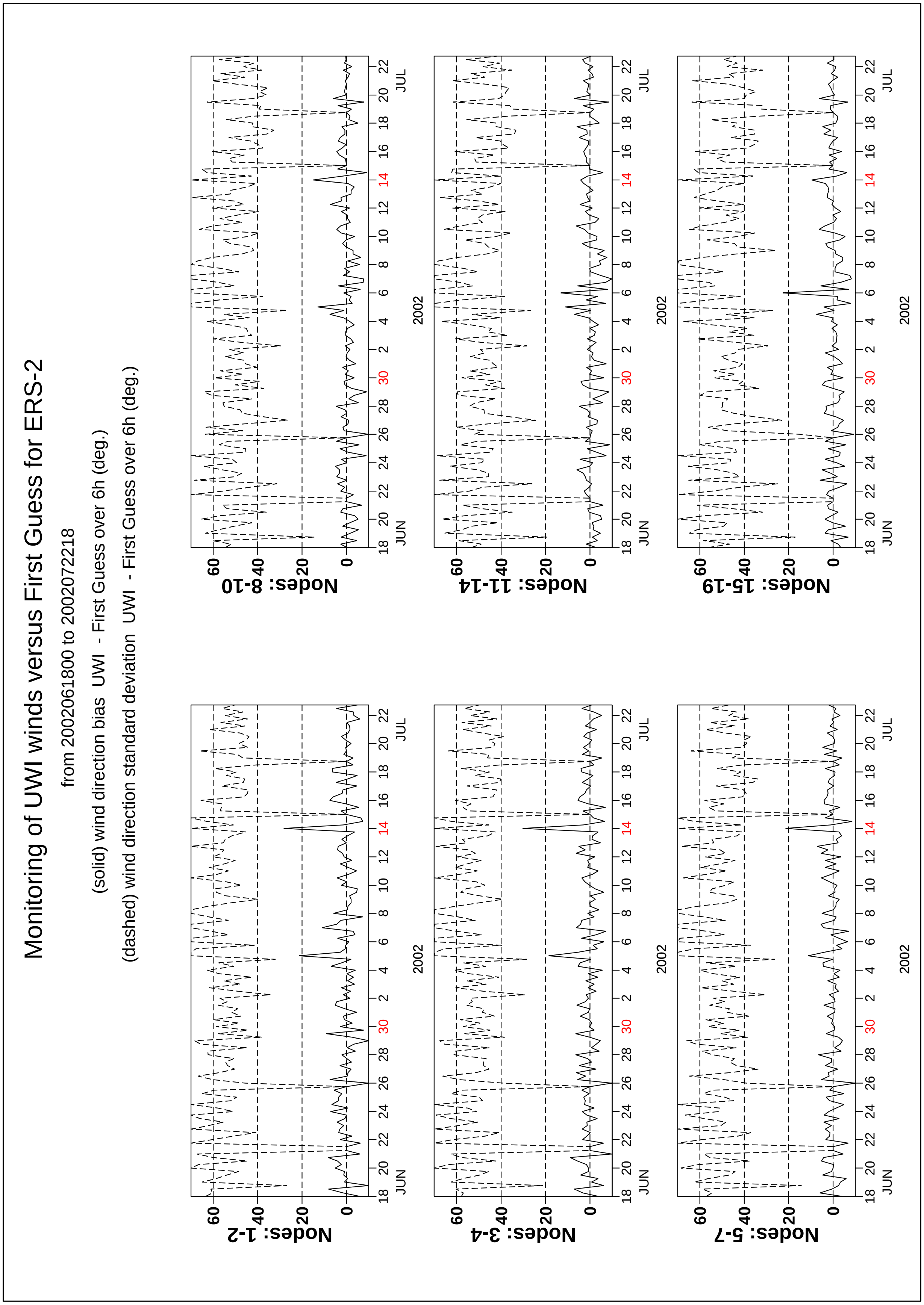

Monitoring of UWI winds versus First Guess for ERS-2
from 2002061800 to 2002072218
(solid) wind direction bias UWI - First Guess over 6h (deg.)
(dashed) wind direction standard deviation UWI - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 3-4
Nodes: 5-7
Nodes: 8-10
Nodes: 11-14
Nodes: 15-19
JUN
JUL
2002

Figure 4

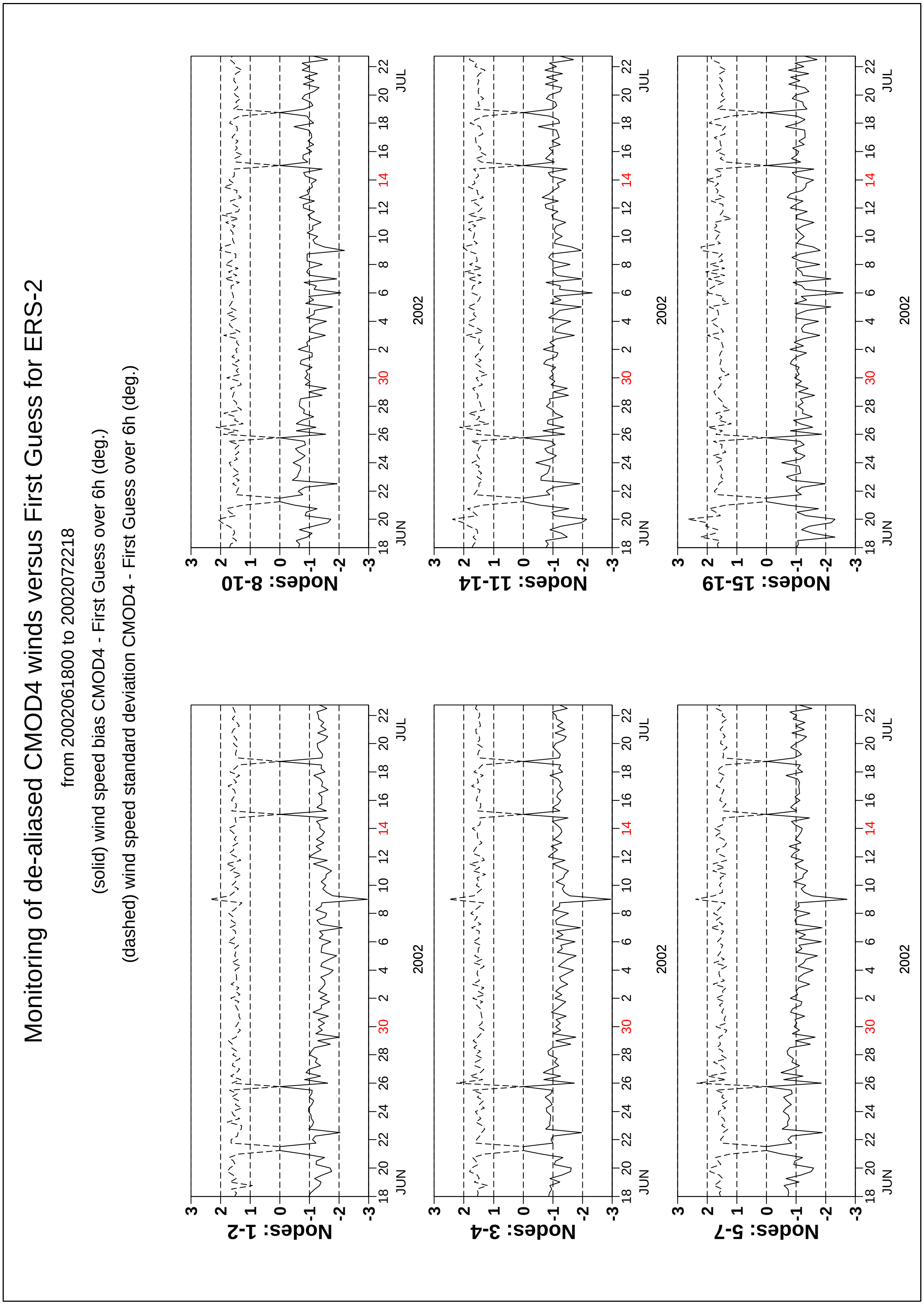
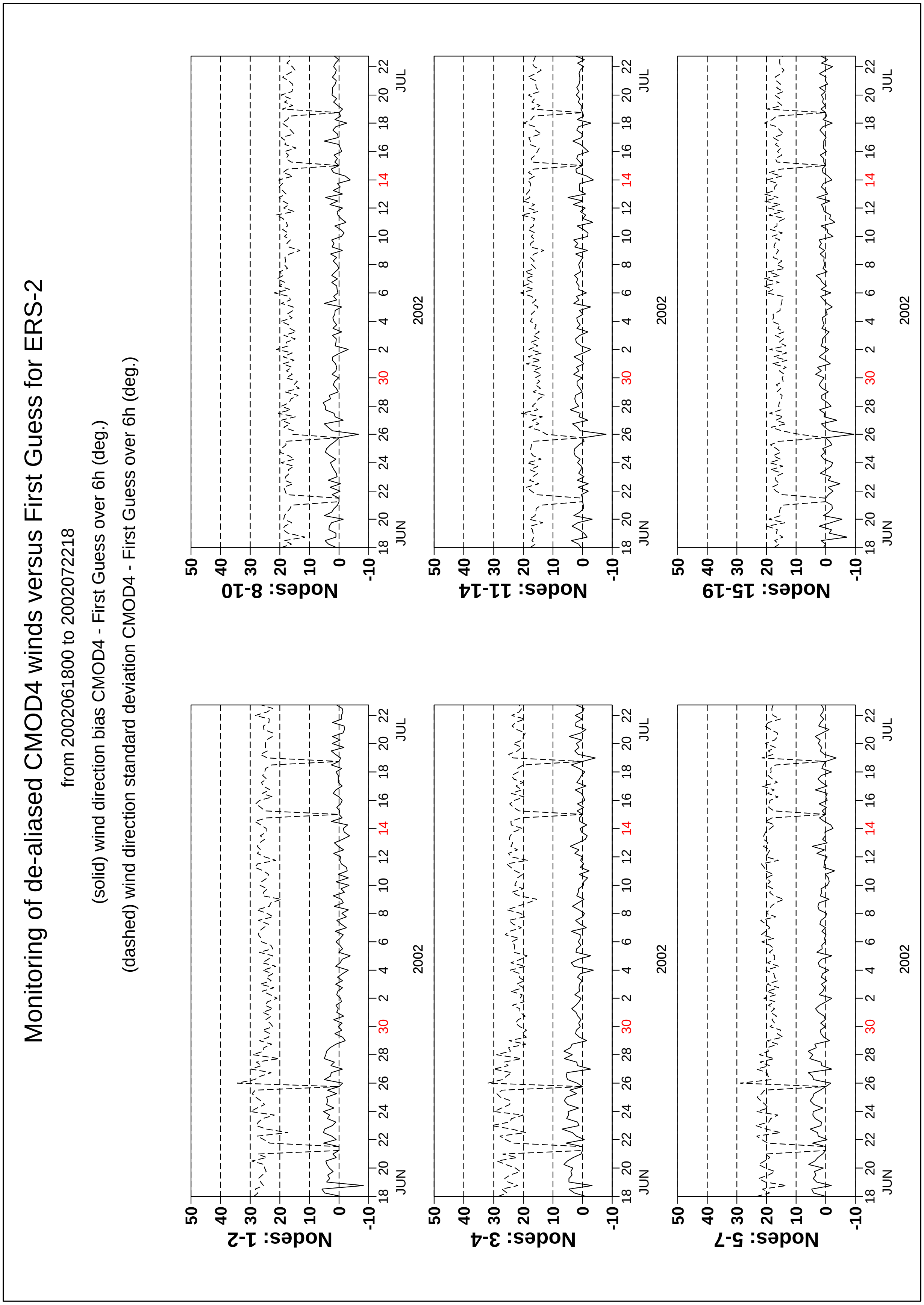
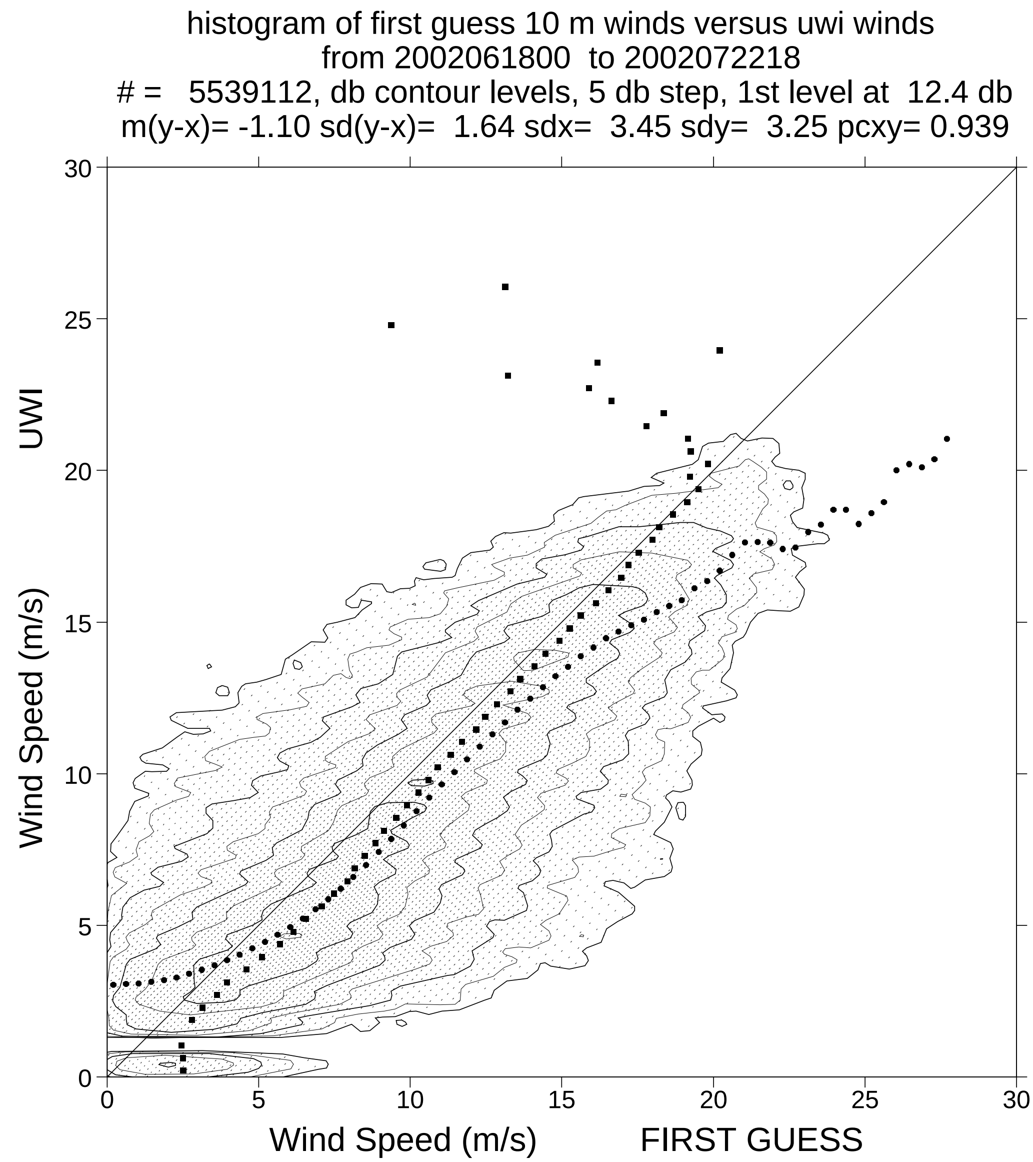

Monitoring of de-aliased CMOD4 winds versus First Guess for ERS-2
from 2002061800 to 2002072218
(solid) wind speed bias CMOD4 - First Guess over 6h (deg.)
(dashed) wind speed standard deviation CMOD4 - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 3-4
Nodes: 5-7
Nodes: 8-10
Nodes: 11-14
Nodes: 15-19
JUN
JUL
2002

Figure 5



Monitoring of de-aliased CMOD4 winds versus First Guess for ERS-2
from 2002061800 to 2002072218
(solid) wind direction bias CMOD4 - First Guess over 6h (deg.)
(dashed) wind direction standard deviation CMOD4 - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 3-4
Nodes: 5-7
Nodes: 8-10
Nodes: 11-14
Nodes: 15-19
JUN
JUL
2002

Figure 6



histogram of first guess 10 m winds versus uwi winds
from 2002061800 to 2002072218
= 5539112, db contour levels, 5 db step, 1st level at 12.4 db
m(y-x)= -1.10 sd(y-x)= 1.64 sdx= 3.45 sdy= 3.25 pcxy= 0.939
UWI
Wind Speed (m/s)
0
5
10
15
20
25
30
Wind Speed (m/s)
FIRST GUESS

Figure 7

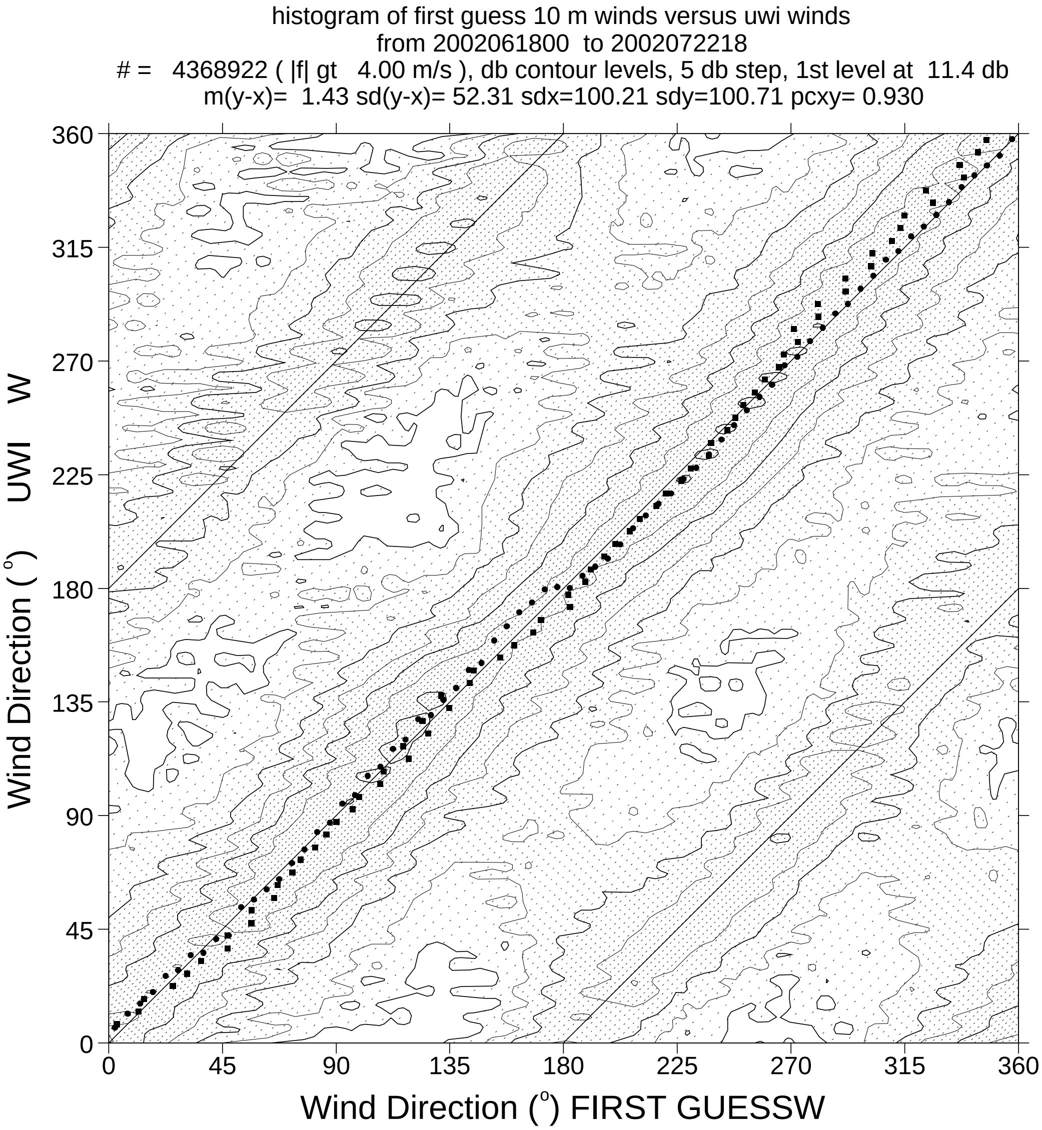

histogram of first guess 10 m winds versus uwi winds
from 2002061800 to 2002072218
= 4368922 (|f| gt 4.00 m/s), db contour levels, 5 db step, 1st level at 11.4 db
m(y-x)= 1.43 sd(y-x)= 52.31 sdx=100.21 sdy=100.71 pcxy= 0.930
Wind Direction (o) UWI W
Wind Direction (o) FIRST GUESSW
0
45
90
135
180
225
270
315
360

Figure 8

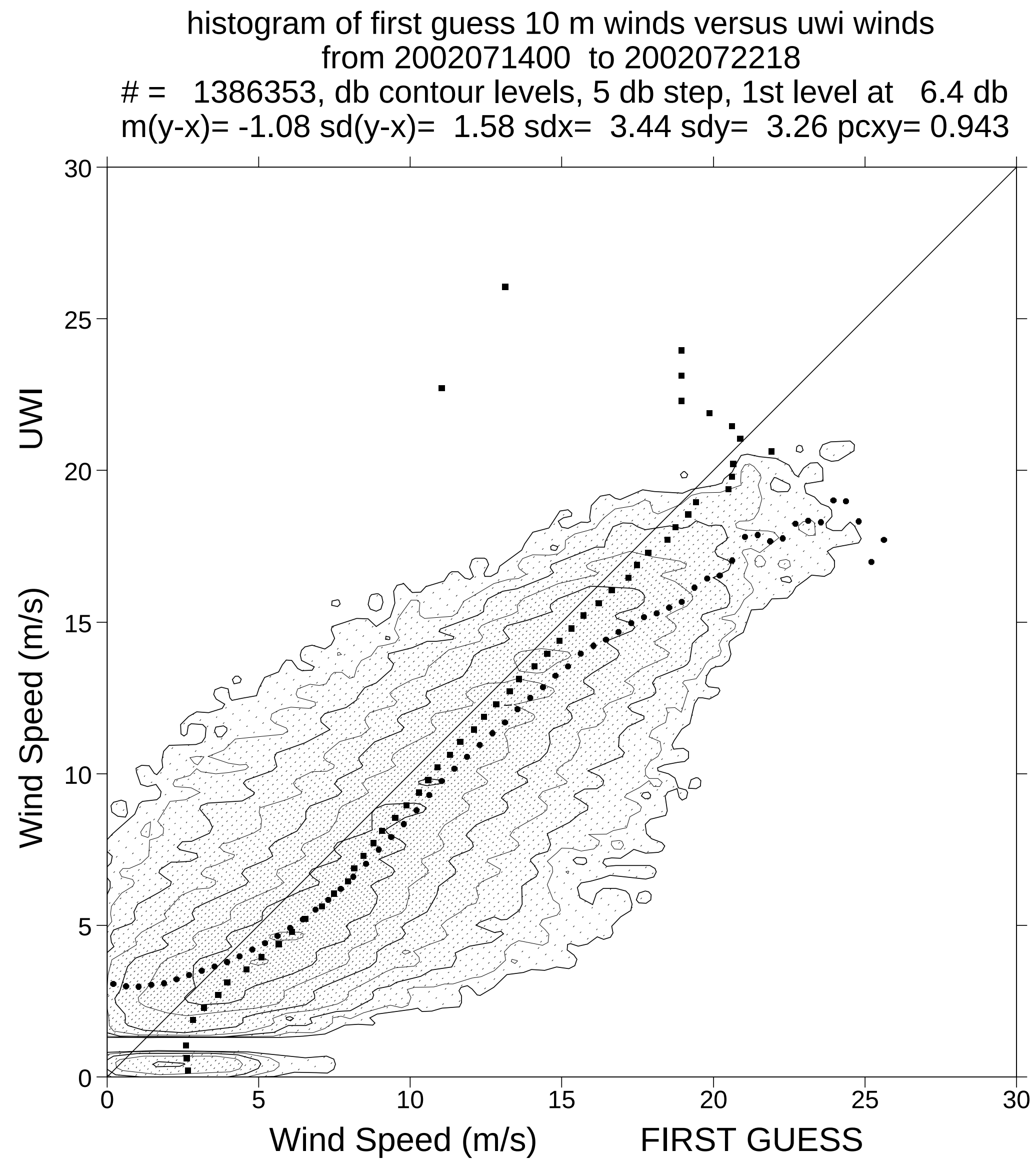

histogram of first guess 10 m winds versus uwi winds
from 2002071400 to 2002072218
= 1386353, db contour levels, 5 db step, 1st level at 6.4 db
m(y-x)= -1.08 sd(y-x)= 1.58 sdx= 3.44 sdy= 3.26 pcxy= 0.943
UWI
Wind Speed (m/s)
0
5
10
15
20
25
30
Wind Speed (m/s)
FIRST GUESS

Figure 9

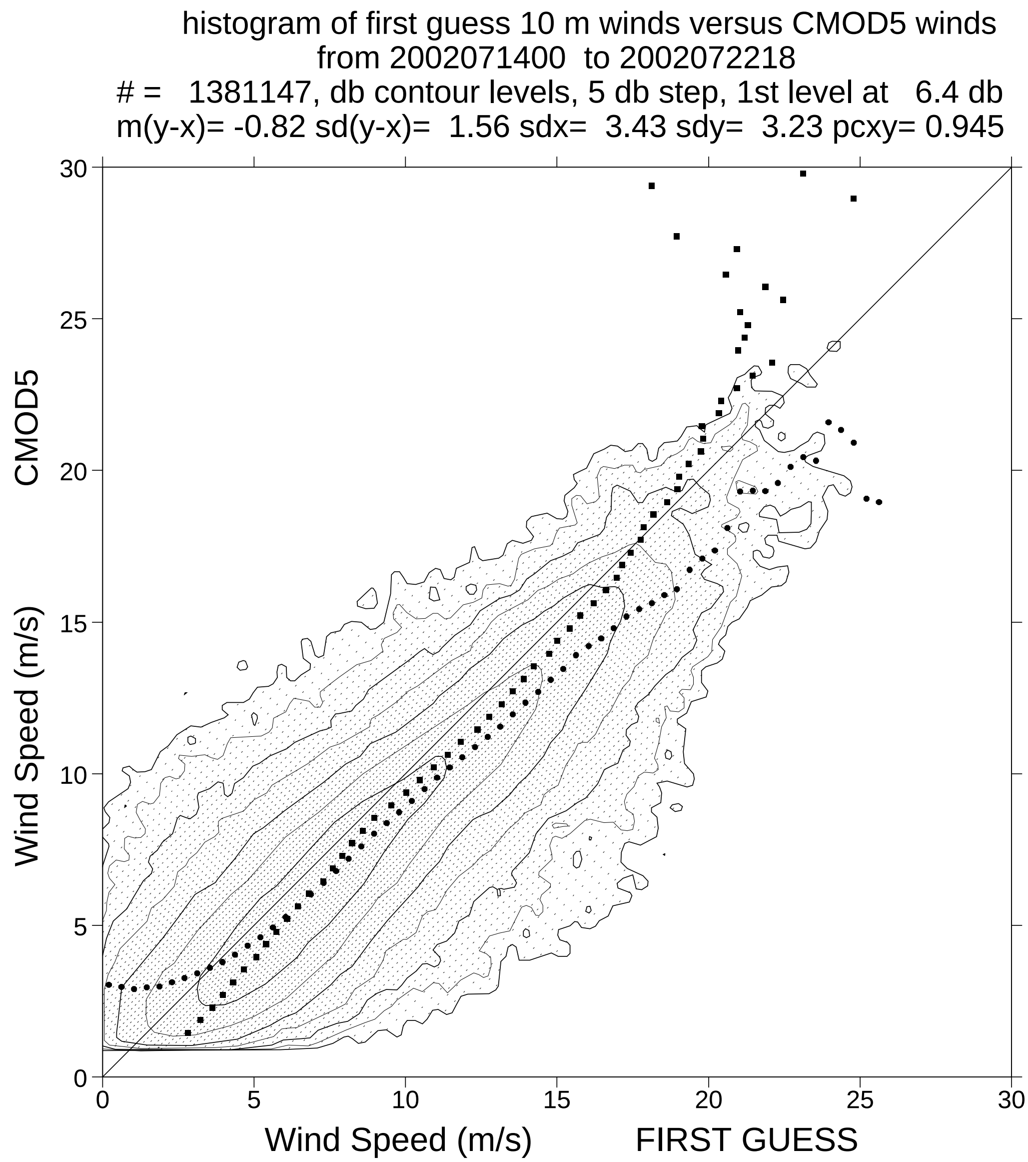

histogram of first guess 10 m winds versus CMOD5 winds
from 2002071400 to 2002072218
= 1381147, db contour levels, 5 db step, 1st level at 6.4 db
m(y-x)= -0.82 sd(y-x)= 1.56 sdx= 3.43 sdy= 3.23 pcxy= 0.945
CMOD5
Wind Speed (m/s)
0
5
10
15
20
25
30
Wind Speed (m/s)
FIRST GUESS

Figure 10